Journal of Fluids Engineering Discussion

Investigation of Wall Induced Modifications to Vortex Shedding From a Circular Cylinder[1]

Guido Buresti.[2] The present paper may be considered a useful contribution to the analysis of the vortex shedding mechanism from a circular cylinder in wall effect. As pointed out by the authors, this situation has received comparatively little attention in the past, in spite of its practical importance.

A very interesting point arising from this work is the small but clear increase in the vortex shedding frequency which was found for decreasing distance from the plane. This result is at variance not only with the hot wire measurements previously reported in [2] and [5], but also with the measurements of the fluctuating forces described in [11] and summarized in [12], and which were carried out with three different thicknesses of the boundary layer on the plane, viz. $\delta/D \simeq 0.1$, 0.45, 1.1; in that case only a the very lowest distances from the plane at which regular vortex shedding could still be observed, i.e., $d/D \simeq 0.3$-0.4, could variation of the Strouhal number be observed, but with values of the same order as the experimental uncertainty, i.e., lower than 3 percent. Particularly striking in the present paper is that the increase in the vortex shedding frequency seems to start at distances as high as 2.0 or even 3.0 diameters, at which all previous investigations had shown the cylinders to be in flow conditions practically coincident in all respects with the isolated cylinder case. Therefore it seems interesting to try to understand which of the differences in experimental conditions might be the cause of these discrepancies. To this end, some further information from the authors might prove useful.

– How did the Strouhal number values for the isolated cylinder cases compare with published data for similar Reynolds numbers?

– Was the upstream velocity of the flow controlled in order to check that no variations occurred when the plane was moved towards the cylinder?

– What was the criterion for the choice of the number (16) of spectra to be averaged to obtain good stationarity? Indeed, when the hot wire signals are taken in the irrotational flow outside the wake, as was done in [2] and [5], a very sharp peak in the spectra is found at the vortex shedding frequency, but in the present work the probe seemed to be positioned at $y/D = 0.5$, i.e., inside the separated wake, and this certainly increased the random turbulent content of the output signals and decreased their stationarity: this might explain why "the frequency of vortex shedding was not quite distinct."

– Did the authors find any variation in the intensity and band width of the peaks in the spectra when the distance from the plane was varied?

The possibility that compressibility effects be responsible for the differences between the present results and those obtained in wind tunnels, at Mach numbers lower than 0.05, seems to be extremely remote. Three-dimensional effects due to the presence of the water free surface, even if probably small, might be more important. The differences in boundary layer thickness cannot completely justify the discrepancies with the results of [5] and [11], either. Therefore, if other experimental causes can be excluded, the differences in Reynolds number might probably be considered as the most probable cause. In any case, this interesting paper certainly confirms two important points, viz. that the variations in Strouhal number induced by the presence of a plane are not large, and that one must always be very careful in drawing definite conclusions about vortex shedding, a challenging and still little understood fluid dynamic phenomenon!

Additional References

11 Buresti G., and Lanciotti A., "Azioni fluidodinamiche su cilindri circolari in presenza del suolo investiti da correnti trasversali," Institute of Aeronautics of the University of Pisa, DIA 77-5, Nov. 1977.

12 Bruschi, R. M., Buresti G., Castoldi A., and Migliavacca E., "Vortex Shedding Oscillations for Submarine Pipelines: Comparison Between Full-Scale Experiments and Analytical Models," Offshore Technology Conference, Houston, 1982, paper OTC 4232.

M. M. Zdravkovich.[3] The new results obtained by Angrilli and coauthors has provided additional information related to the Strouhal number as affected by the vicinity of a parrallel wall. The experiments were carried out in the Reynolds number range from 2860 to 7641 which could be termed as the lower subcritical range. The increase of Strouhal number with decreasing the gap to diameter ratio was in variance with the constant Strouhal number found in the upper subcritical range from 2.15×10^4 to 2×10^5 in (2) and (5). However Shaw [13] estimated the shedding frequency behind the circular cylinder in a water channel by using surface flow visualization and found systematic increase of Strouhal number with decreasing gap to diameter ratio. The Reynolds number range was lower subcritical overlapping with that of the authors. Hence it appeared that the effect of the wall vicinity on the Strouhal number was different in the lower and upper subcritical range.

The peculiar feature of the lower subcritical range has been noted by Schiller and Linke [14] in 1933. They showed convincingly by measuring static pressure profile across the nearwake that the length of the vortex formation region was drastically reduced as the Reynolds number increased from 2×10^3 to 1.4×10^4. This finding was verified by Bloor and

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[1] By F. Angrilli, S. Bergamaschi, and V. Cossalter, published in the December, 1982 issue of the JOURNAL OF FLUIDS ENGINEERING, Vol. 104, pp. 518–522.

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Gerrard [9] by using three different methods to determine the length of the vortex formation region. The drag coefficient increased from 0.9 to 1.15 within the same Reynolds number range [14]. However, the reduction of the formation length and the increase of drag coefficient were also promoted at lower Reynolds numbers by attaching thin trip wires at 90 deg from the stagnation point [14]. It may be argued that the rise in Strouhal numbers observed by the present authors was produced by the shrink of the nearwake as triggered by the wall proximity. The confirmation of this argument appeared in the last statement of the conclusions by the authors.

The authors tried to compare their results with those reported by Goktun [15] and measured at $\mathrm{Re} = 1.53 \times 10^5$. The smaller increase in Strouhal number, $f/f_0 = 1.04$, found by Goktun [15] at $\delta/D = 0.5$ had different physical origin. The upper end of the subcritical range led to the precritical beginning of transition to turbulence in the boundary layers. The latter started to displace the separation points on the cylinder in the downstream direction and the resulting narrower nearwake produced slight increase in the Strouhal number.

Finally I have two questions to the authors:

1. What was the actual value of the Strouhal numbers measured on isolated cylinders at the three Reynolds numbers tested?
2. Whether the departure between curves *b* and *c* in Fig. 10 was more pronounced when δ/D was decreased below one.

Additional References

13 Shaw, T. L., "Wake Dynamics of Two-Dimensional Structures in Confined Flow," *Proceedings 14th Congress IAUR*, 1971. Vol. 2, pp. 41-48.

14 Schiller, L., and Linke, W., "Pressure and Friction Drag of Cylinders at Reynolds Numbers 5,000 to 40,000 (in German)," *Zeitschrift fur Flugtechnik and Motorluftschiffahrt*, Vol. 24, No. 7, 1933, pp. 143-148.

15 Goktun, S., "The Drag and Lift Characteristics of a Cylinder placed near a Plane Surface," MSc thesis, Naval Postgraduate School, Monterey, Calif., 1975.

Authors' Closure

The authors wish to thank G. Buresti and M. M. Zdravkovich for their discussions.

The questions which have been formulated are mostly related to some aspects of the experimental procedure, so that the response will try to clarify each point separately.

- No appreciable variation of the Strouhal number with Re was detected for the isolated cylinders. In fact the differences were in the range of uncertainty of the velocity (±4 percent) and frequency measurements (0.7 ÷ 2 percent depending on the frequency value) and the values varied from 0.202 to 0.216.
- The upstream water velocity was controlled and no detectable variation could be found as a function of the gap size.
- The number of spectra to be averaged was chosen to be 16 because this was the minimum in order to achieve perfect repeatibility in relation to the amplitude and frequency resolution of the F.F.T. analyzer. The probe was positioned around $y/D = 0.5$ because this location was found to be the one where the peaks in the frequency spectra were the sharpest.
- No systematic variation of the bandwidth of the peaks was found (see Fig. 4 for an example).
- The authors did not perform systematic measurements on the maximum value of θ at values of d/D different from one. This was because the determination of each point was very time consuming, requiring the processing of data obtained after about 120 minutes of data acquisition.

Effects of Surface Solidification on the Stability of Multilayered Liquid Films[1]

F. I. P. Smith.[2] This paper extends the work of earlier papers the author had written conjointly. Here, the uppermost layer now has a solidified liquid-air interface which has the effect of stabilizing interfacial shear waves or destabilizing gravity-capillary waves associated with top-heavy stratification.

It would be of interest if the author had compared his result by taking $\beta = 0$ with that of Yih who found instability generated by viscosity variation in superposed layers flowing horizontally. Yih has a section on moving upper boundaries and concludes with a fairly detailed discussion on the various effects arising. Yih, C. S., "Instability due, to Variation of Viscosity," *Journal of Fluid Mechanics*, Vol. 27, 1967, p. 337.

(In the preprint examined an obvious error has crept into the second last sentence in the paragraph containing equation (6).)

Author's Closure

The author is grateful to Dr. Smith for pointing out an obvious error in the second to last sentence in the paragraph containing equation (6) of the original manuscript. The right sides of the inequality signs in this sentence should have been 1 instead of 0. As to the suggestion that we compare the results for $\beta = 0$ and $\gamma_2 = 1$ with that of Yih, we point out that there will be no flow when $\beta \to 0$ in our problem. While the present flow is driven by gravity the flow studied by Yih was driven by external shear force or pressure gradient.

Simple and Explicit Formulas for the Friction Factor in Turbulent Pipe Flow[1]

Don J. Wood.[2] It appears that this paper incorrectly claims the presentation of a significantly improved explicit friction factor formula. The statement that all the existing explicit equations are either simple and not accurate or accurate and not simple is refuted by the author himself in the paper. The equation presented by Swamee and Jain in reference [4] is certainly equivalent in simplicity to the one offered by the author and the claim of superior accuracy for the author's relation is simply not significant. The author states that his relation has maximum error of 1.5 percent compared to the Colebrook-White formula while the Swamee-Jain relation has a maximum error of nearly 3 percent. The author further states that Colebrook-White formula may be 3-5 percent or more in error compared to experimental results. Based on this reasoning it does not appear that the author contribution is of any great significance, since the Swamee-Jain formula is a more than adequate relationship. The author does present a formula for the smooth to rough transition which appears to represent the transitions well. However, it includes a factor *n*

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[1] By S. P. Lin, published in the March, 1983 issue of the JOURNAL OF FLUIDS ENGINEERING, Vol. 105, pp. 119-121.

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[1] By S. E. Haaland, published in the March, 1983 issue of the JOURNAL OF FLUIDS ENGINEERING, Vol. 105, pp. 89-90.

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